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(54) Abstract Title
Statistically monitoring a communications system against a variable threshold

(57) A communications system is monitored using statistics derived from operating parameters, conditions and event data within the communications system. The statistics are collected from the communications system and statistically analysed with reference to a threshold. The threshold is varied and in one embodiment this variation is represented as a function of the sample size. Different functions may be given to different ranges of sample sizes so that for example the threshold in a first range 410 may take the form of a linear equation, whilst in the second range 420 it may be constant. The communications system may be cellular and the cells may be grouped into respective groups having different thresholds. The statistical data may relate to the number of calls requested, setup, in progress and dropped etc.

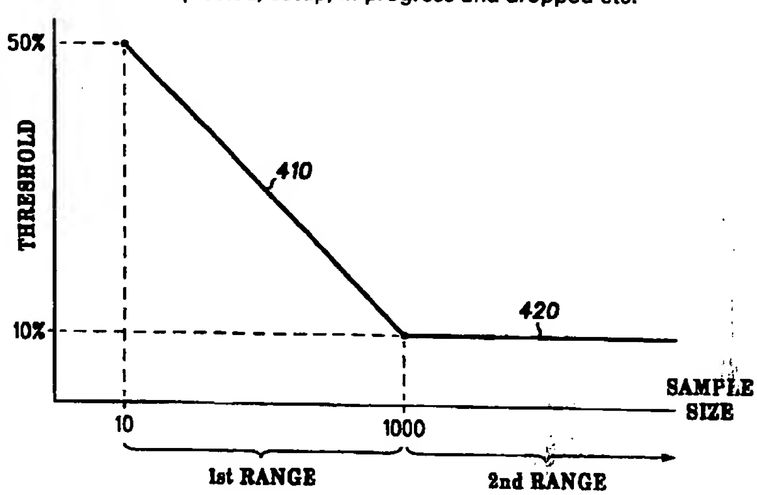

FIG. 4

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

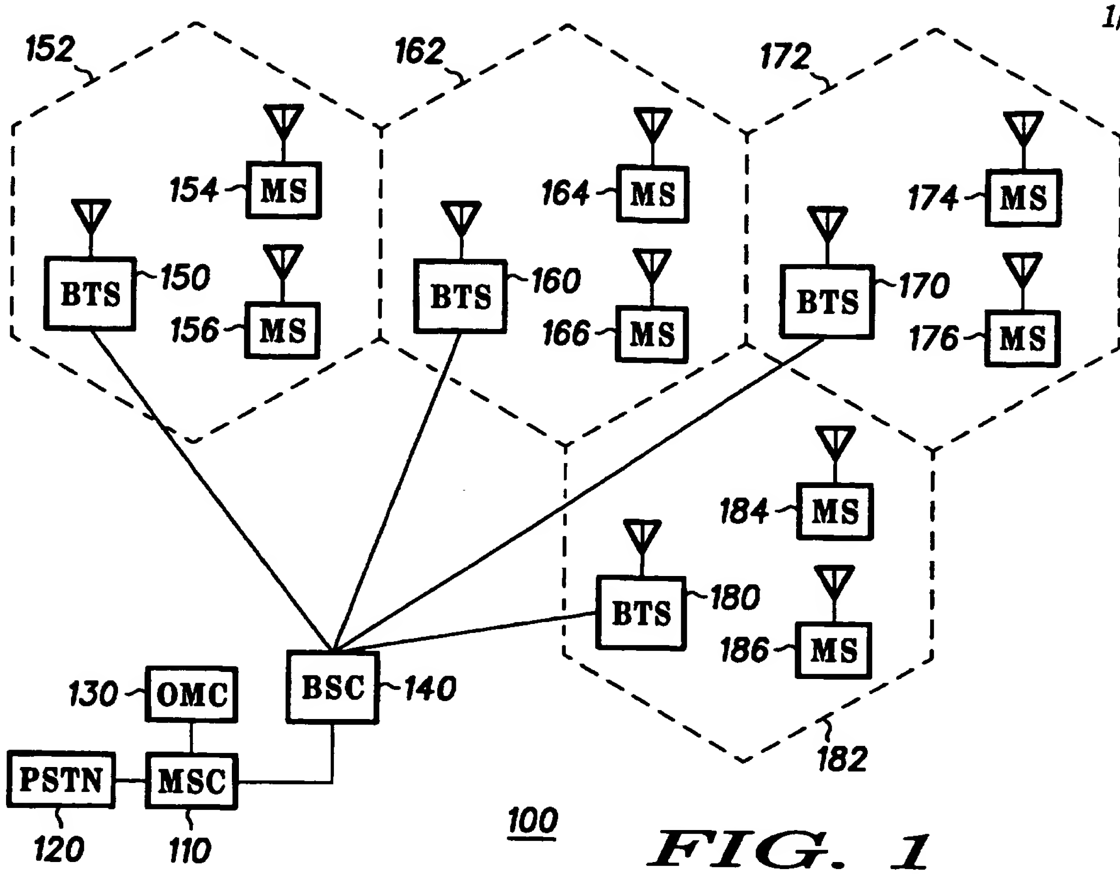

FIG. 1

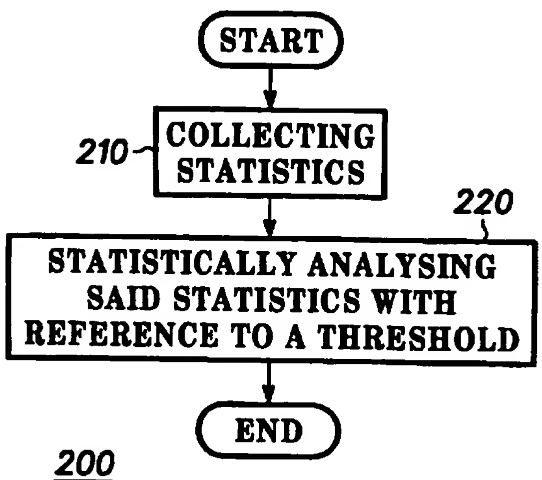

FIG. 2

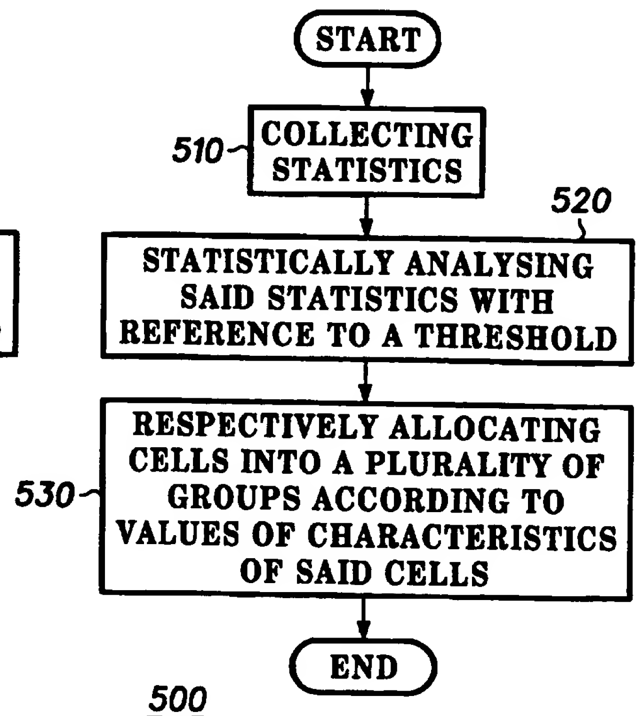

FIG. 5

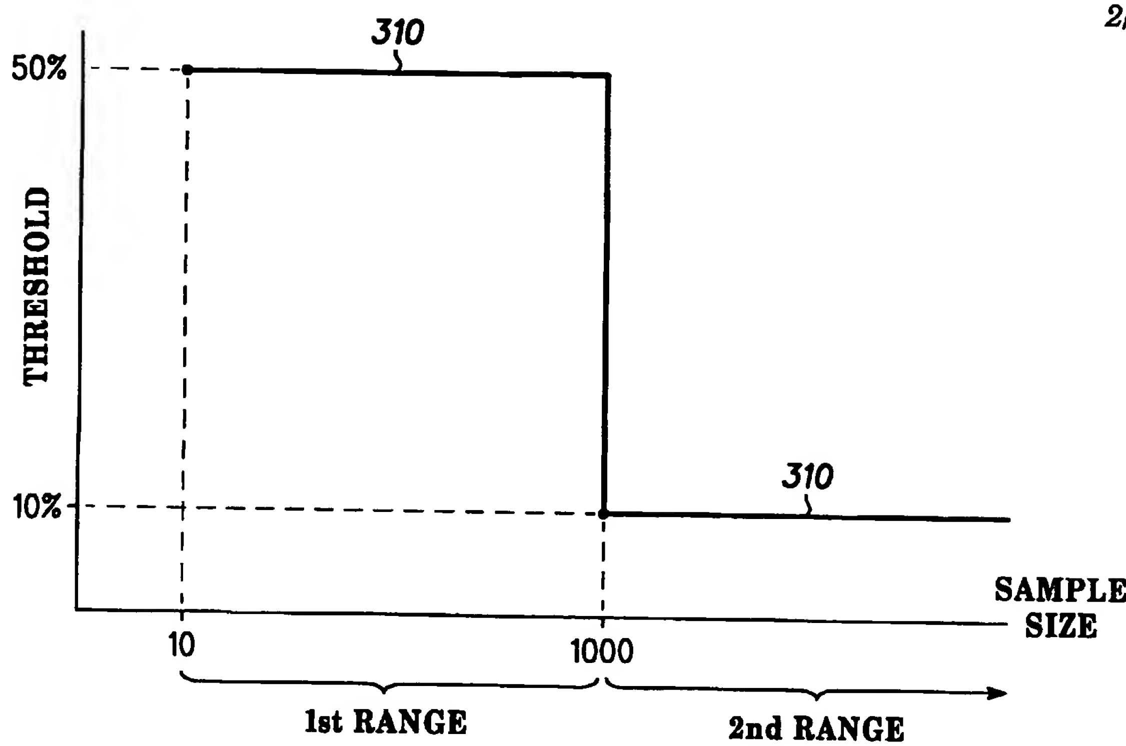
310
50%
THRESHOLD
10%
310
SAMPLE SIZE
10
1000
1st RANGE
2nd RANGE

FIG. 3

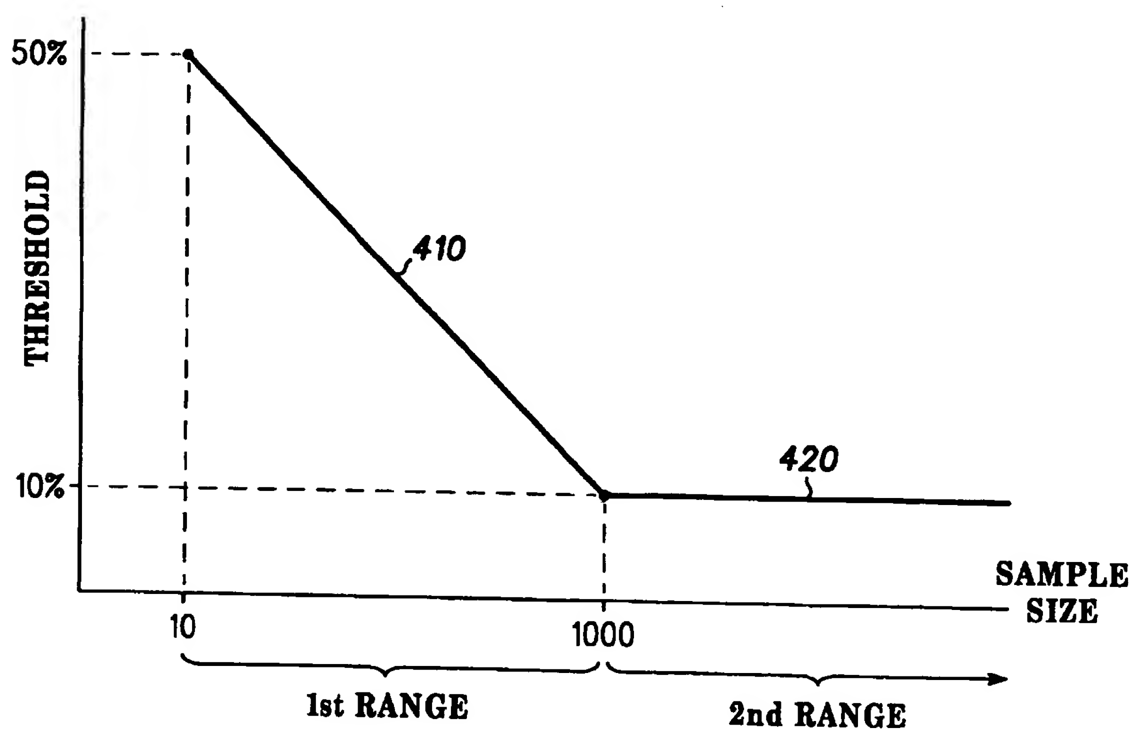
50%
THRESHOLD
410
420
10%
SAMPLE SIZE
10
1000
1st RANGE
2nd RANGE

FIG. 4

MONITORING A COMMUNICATIONS SYSTEM

Field of the Invention

The present invention relates to a method of monitoring a communications system using statistics derived from the communications system. The present invention also relates to an apparatus for monitoring a communications system using statistics derived from the communications system. The present invention is particularly suitable for a cellular communications system, and for example is applicable, but not limited to, a GSM system.

Background of the Invention

In communications systems, large amounts of data are produced with respect to a multitude of operating parameters, conditions and events in the system. Examples include data related to number of calls requested, number of calls successfully set-up, number of calls in progress, number of dropped calls, and so on. It is useful to collect some or all of this data for analysis so as to provide information about the system and its performance. The data that is collected and analysed represents statistics derived from the communications system. The statistics can in theory be all of the available data, but usually in practice is some of the available data, most usually selected by some form of statistical sampling procedure.

In order to monitor the performance of some aspect of a communications system, the statistics are analysed with reference to a threshold. Then if the threshold is exceeded, this fact can be indicated and attention given to the situation. Such indication can involve human operators or can be entirely automatic. The monitoring of the communications system can be carried out in real time, wherein statistics are collected on an ongoing basis and compared to the threshold continually, or at least such comparison is repeated at regular

intervals, say, or the monitoring can be carried out off-line after a discrete amount of statistics have been collected.

One type of communications system is a cellular communications system. In a cellular communications system, the area over which service is provided is divided into a number of smaller areas called cells. Typically each cell is served from a base transceiver station (BTS) which has a corresponding antenna or antennas for transmission to and reception from a user station, normally a mobile station. Presently established cellular radio communications systems include GSM systems (Global System for Mobile Communications). Monitoring of cellular communications system is particularly advantageous because the mobility of user stations, and ongoing interactions between different cells, produce ever changing performance situations in addition to those characteristics, such as faults and capacity levels, which are also found in non-cellular systems.

However, problems arise in known methods employing thresholds, particularly in methods using at least some degree of automation. Such thresholds can be clumsy in their effect, and produce results that are not always appropriate.

One disadvantage arising from the use of a threshold is that when sample sizes are small, assessment with respect to a threshold can produce statistically distorted results, in that the naturally occurring statistical variations in a small sample size can give a false crossing of a threshold even when the system under consideration is not fundamentally crossing the threshold. In known systems this problem is countered by excluding too small sample sizes from analysis in the monitoring process, or alternatively by increasing the sample size.

Another disadvantage arising from the use of a threshold is that a threshold that is appropriate in one area of the system may not be appropriate in another part of the system.

Summary of the Invention

The present invention addresses some or all of the above disadvantages, by virtue of providing that the threshold is varied.

According to one aspect of the present invention, there is provided a method of monitoring a communications system using statistics derived from said communications system, as claimed in claim 1.

According to another aspect of the invention, there is provided an apparatus for monitoring a communications system using statistics derived from said communications system, as claimed in claim 11.

Further aspects of the invention are as claimed in the dependent claims.

The present invention tends to provide a measure of improvement to the use of a threshold, with ensuing advantages. By varying the threshold, disadvantages arising from the fixed nature of known thresholds are overcome.

More particularly, when according to one aspect of the present invention the threshold is varied as a function of a sample size of said statistics derived from said communications system, then the effect is to make advantageous use of data that would need to be discarded in known methods, whilst avoiding or reducing disadvantages that arise from the stronger effect of statistical variation at lower sample size. This is of powerful benefit in the case of real time monitoring since the provision for monitoring based on smaller sample size

allows quicker detection of faults or other system changes, disturbances or phenomena, compared to known methods.

Furthermore, when according to another aspect of the present invention the method comprises the step of respectively allocating cells of said cellular communications system into a plurality of groups according to values of characteristics of said cells, and wherein variation of said threshold comprises employing a respective group threshold value for each respective one of said plurality of groups, then the effect is to advantageously provide different threshold levels in different geographical areas of the system. This is beneficial since, for example, it is advantageous if different call set-up failure rates are indicated in an urban area compared to a rural area.

Yet further, in a cellular communications system employing many cells, which cells moreover may often be changed in their nature due to the insertion of further cells, the setting-up of a monitoring plan involving different thresholds for different cells would be very time consuming and prone to errors. This further disadvantage is alleviated when, according to yet another aspect of the present invention, said cells are allocated into said plurality of groups automatically and wherein said values of characteristics of said cells comprise statistics collected automatically from said cellular communications system.

Additional specific advantages are apparent from the following description and figures.

Brief Description of the Drawings

FIG. 1 is an illustration of a cellular communications system which is in accordance with the present invention.

FIG. 2 is a process flow chart of an embodiment of the present invention.

FIG. 3 is a schematic illustration of threshold variation as a function of a sample size in an embodiment of the present invention.

FIG. 4 is a schematic illustration of threshold variation as a function of a sample size in another embodiment of the present invention.

FIG. 5 is a process flow chart of another embodiment of the present invention.

Description of Embodiments of the Invention

The embodiments hereinafter described relate to a cellular communications system which is a GSM system, although it will be appreciated that the invention is not limited to such a system and can equally be used in non-cellular communications systems, including public switched telephone networks, private network radio systems, and so on. The invention can also be used in other cellular communications systems, including other time division multiple access (TDMA) systems, code division multiple access (CDMA) systems, or combined TDMA-CDMA systems.

FIG. 1 illustrates part of a cellular communications system 100 including a mobile services switching centre (MSC) 110 to which is coupled a public switched telephone network (PSTN) 120 and an operations and maintenance centre (OMC) 130. Further coupled to MSC 110 is base station controller (BSC) 140. Yet further, base transceiver stations (BTS) 150, 160, 170 and 180 are coupled to MSC 110 through BSC 140. Each BTS 150, 160, 170 and 180 provides a respective coverage area, each known as a cell 152, 162, 172, 182 of the cellular communications system. By convention, each cell 152, 162, 172, 182 is shown in FIG. 1 in the form of a hexagon, but in real systems the shape of each cell will

depend on a number of details such as transmitter power, geographical details, and so on.

Two user stations, in the form of mobile stations, are shown in each cell – mobile stations 154 and 156 in cell 152, mobile stations 164 and 166 in cell 162, mobile stations 174 and 176 in cell 172, and mobile stations 184 and 186 in cell 182.

The method of monitoring the communications system using statistics derived from said communications system according to a first embodiment is shown in process flow chart 200 of FIG. 2. Referring to FIG. 2, function box 210 shows the step of collecting statistics from said communications system. In the present embodiment the statistics are derived from the communications system by virtue of OMC 130 retrieving data corresponding to attempted call set-ups by and to the above mentioned mobile stations. Such data is originally produced in any or all of BTS 150, BTS 160, BTS 170, BTS 180, BSC 140 and MSC 110, and is transmitted to MSC 110 where it is collected by OMC 130. OMC 130 further carries out statistical sampling of the data, in the present embodiment determining a rate of success of call set-up, thus collecting the relevant statistics which in the present embodiment thereby comprise the rate of success of call set-up in cells 152, 162, 172 and 182.

Other types of data that could be employed include drop call rate, handover success rate, traffic channel congestion, signalling channel congestion, paging volume and call volume.

The next step is that of statistically analysing said statistics with reference to a threshold, as shown at function box 220 of FIG. 2. In the present embodiment, let us assume the system operator considers a call set-up rate of 90% success, i.e. 10% rate of failure, to be acceptable. It is noted that many commercial systems achieve a higher rate than this in practise, but the level of 90% is used herein for

the sake of clarity. Thus, when the amount of statistics collected, starting from any given start point, such as a given time of a new day, for example 6 a.m., is sufficiently high that discrepancies from statistical variation are avoided, the system operator is able to set a threshold value of 10% failure rate. Thus, if on analysing the statistics, it is determined that more than 10% of attempted call set-ups have failed, then analysis with reference to the threshold indicates unacceptable performance and this is indicated to the system operator. In the present embodiment this analysis is carried out at OMC 130, and the indication is made by means of alarm indications computer screen information provided to human operators located at OMC 130. However, it is to be appreciated that in other examples such indication can be entirely automatic and can be directly interfaced with automatic equipment responses.

However, when the collected statistics represent a small sample size, then statistical variations do have an effect, to the extent that a call set-up failure rate of more than the threshold of 10% can be determined by the statistical analysis even though in reality the system is operating healthily at a value lower than the threshold. For example, to exaggerate for the sake of understanding, consider the extreme case where the sample size was just 10 attempted call set-ups, in a system where on average call set-up failure rate was at an acceptable 5% level. Then, if by mere chance, i.e. effect of statistical variation, 2 of the 10 particular call set-ups failed, then according to the collected statistics the failure rate would be analysed as 20%, thus the threshold of 10% would be exceeded. To alleviate this effect, in the present embodiment the threshold is varied, more particularly the threshold is varied as a function of a sample size of said statistics derived from said communications system. In the present exaggerated example, a simple way of implementing this aspect of the invention is to set the failure rate threshold at the standard 10% level for sample sizes over, say, 1000 call set-ups (range 2), and to set the threshold at say a 50% level for sample size between 10 and 1000 (range 1). Thus for high sample sizes the same accuracy is achieved as

in known methods, but for sample sizes between 10 and 1000 analysis is capable to an extent of indicating catastrophic failure levels (here higher than 50%) whilst vastly alleviating any false-alarm effect from statistical variation.

It can be seen from FIG. 3, which illustrates the threshold 310 as a function of the two ranges described above, that the form in which the threshold is varied as a function of the sample size is essentially a stepped function, in which within each range the threshold is of the same function, namely constant, albeit it at different absolute levels.

Alternatively, said sample size is divided into a plurality of ranges and said function of a sample size comprises respective functions for each respective range. In this case within each range there is a respective function, which functions are not all necessarily merely constant. In one version of the present embodiment, one or more of the respective functions are comprised of a linear equation. This is shown schematically in FIG. 4, where it can be seen that the threshold 410 in the first range, i.e. sample size between 10 and 1000 is comprised of a linear equation of the form $y = mx + c$, where y is threshold, x is sample size, m is gradient and c is the y intercept, and the threshold 420 in the second range, sample size of 1000 and beyond, is constant. (To avoid confusion, it is also noted that the sample size axis in FIGS. 3 and 4 is linear, i.e. it is not to be considered a logarithmic scale, rather it is merely coincidence that the two values shown are multiples of 10.) By virtue of the linear equation function, the trade-off and balance between being able to make use of smaller sample sizes whilst optimising accuracy of interpretation is further improved and enhanced.

It is to be appreciated that in other versions of the present embodiment, the linear equation can be replaced by other functions, e.g. logarithmic functions or exponential functions, according to the requirements of the particular system under consideration.

The above values and functions have been shown in the form of an exaggerated example. Clearly, in practice, the different values, functions and ranges will be chosen by the skilled person according to the requirements of the particular system under consideration, and will accordingly give advantages even when variations introduced into the threshold are proportionally less dramatic than in the above example. Also, in practise the number of ranges in the plurality of ranges will often be more than the two described above.

Also, in some cases the threshold under consideration will be one defined in terms of success rate, in which case the gradients or steps in the threshold function will be inverted compared to the above examples.

In the above examples, sample sizes below 10 are not included in the analysis. However, if the desired trade-off is one in which as low a sample size as possible was required to be analysed, despite increased false-alarm or discrepancy rates, then range 1 as described above can be extended down to a sample size of 1. In this case although a certain level of false indications may still be expected, this level will still be reduced by the variable threshold of the present invention compared to if the threshold was not varied. Also, there will be situations where the statistics under consideration relates to data which lends itself to high accuracy threshold assessment under the present invention, even for, say, one sample. One such situation is for example where the statistics are derived from data related to relative transmission strength from either a BTS or a mobile station, where an individual value is on a continuous scale itself, although improved statistical accuracy is achieved at high sample sizes by consideration of average values.

In one version of the presently described first embodiment, the threshold is varied by means of an operator system from which said function of a sample

size and values corresponding to said function can be ascertained by an operator using said operator system. One way of implementing this is for an operator system to be provided at OMC 130 for use by an operator. In addition to the operator system containing the technical means for varying the threshold, the operator system is also provided with a graphical user interface (GUI), which provides a display content which is schematically along the lines of the drawings shown in FIGS. 3 and 4. By clicking via a computer mouse anywhere on the threshold 310, 410 or 420, the operator is provided on the display with the values of the applicable threshold and the sample size corresponding to the point on the threshold at which he has clicked the mouse. Also, in the case of ongoing real time monitoring, the GUI can be arranged such that the applicable sample size and threshold at that moment is automatically displayed, along with any information about the results being achieved relative to the threshold. Specification of the details of the threshold variation implemented by the operator system can be either pre-programmed, programmable by the operator, or a combination of pre-programmed and programmable. Furthermore, by means of the GUI, the operator can select or amend factors such as the points at which the respective ranges start and finish, and so on. One way of doing this would be by dragging and dropping using a computer mouse.

A second embodiment of the present invention will now be described. The method of monitoring the communications system using statistics derived from said communications system according to the second embodiment is as shown in process flow chart 500 of FIG. 5, and comprises the step of collecting statistics from said communications system as shown in function box 510 of FIG. 5, and the step of statistically analysing said statistics with reference to a threshold, as shown at function box 520 of FIG. 5. Also, in the second embodiment the statistics again comprise the rate of success of call set-up in cells 152, 162, 172 and 182 of communications system 100 as shown in FIG. 1, and the threshold again comprises an acceptable level of failure rate of call set-up.

In the present embodiment, let us assume cells 152 and 162 represent busy urban cells, whereas cells 172 and 182 represent less busy rural cells. Under the present invention it is advantageous to vary the threshold such that a call set-up failure rate of, say, 10% is acceptable in the rural cells 172 and 182, whereas in the busy urban areas a better service is required, hence only a failure rate of 5% or less is acceptable in the urban cells 152 and 162. In this respect the second embodiment further includes the step of respectively allocating cells of said cellular communications system into a plurality of groups according to values of characteristics of said cells, as shown at function box 530 of FIG. 5. In the present case, urban cells 152 and 162 are allocated into a first group, called the urban group, and rural cells 172 and 182 are allocated into a second group called the rural group, i.e. the number of groups in the plurality of groups is in this particular example is two. The characteristic employed in making this allocation are, in the present case, a traffic channel usage level which is derived from stored data from the relevant cells. Other characteristics can be used instead or in addition. For example, in the present case where the groups are formulated according to the concept of rural or urban, further refinement can be introduced by including a characteristic related to the time profile of calls recorded from respective cells, e.g. day-time compared to evening and night time, also average call duration or average calling distance. Another characteristic that can be included or used instead is whether a cell is a macro-cell or a micro-cell. Yet another characteristic that can be included or used instead is details of the equipment type at that cell, for example it may be advantageous to use a different threshold for updated equipment compared to older equipment. On the basis of such grouping into rural cells and urban cells, in the second embodiment variation of said threshold comprises employing a respective group threshold value for each respective one of said plurality of groups, as already explained above where a threshold of 5% is applied to the urban cells and a threshold of 10% is applied to the rural cells.

The above described second embodiment is in the form of a relatively simple scenario. Clearly, in practice, the different characteristics, and form of groupings, will be chosen by the skilled person according to the requirements of the particular system under consideration. Also, in practise the number of groups in the plurality of groups will often be more than the two described above, and such larger numbers will provide for more refined application of the present invention. Another example of groupings is one with four groups, titled respectively "quiet", "normal", "busy", and "micro".

Also, although in the description above only four cells are included, normally a cellular communications system will include many more such cells. Also, the geographical boundaries of such cells, and other details such as frequency settings, power levels, and so on may often be changed in their nature due to the insertion of further BTSs in the system thus forming new cells. Thus the setting-up of a monitoring plan involving different thresholds for different cells is very time consuming and prone to errors. This further disadvantage is alleviated when, according to an optional aspect of the second embodiment, said cells are allocated into said plurality of groups automatically, and said values of characteristics of said cells comprise statistics collected automatically from said cellular communications system. In the present example the traffic channel usage data, constituting the characteristics of the cells, are collected automatically by BSC 140 and fed back from BSC 140 to MSC 110, where they are further fed to OMC 130. The means for automatically allocating the cells into the described plurality of groups can consist of standard processing equipment, including computer equipment. Such processing means, including any protocols or algorithms, are provided by the skilled person according to the requirements of the system under consideration, and in the usual manner the skilled person will also take into account previous experience gained in the system under consideration, or in other similar systems, or in simulations or trials or the like.

Also, the above described automatic allocation into groups can be augmented, amended, verified or fine-tuned by additional individual allocation of cells into the groups, under some degree of direct operator influence. One example is where individual cells represent special situations, such as a cell serving in-building coverage for a stock exchange or for a VIP.

It is to be appreciated that in both the first and second embodiments above, the particular communications system components, the aspect monitored, and the particular thresholds considered are merely exemplary. The present invention is applicable to any aspects of a communications system in which performance monitoring is carried out with reference to thresholds.

It is also to be appreciated that the specific system configuration shown in FIG. 1 with reference to each of the above embodiments is merely exemplary, and the present invention is applicable to other system and network configurations. For example, OMC 130 may be coupled directly to BSC 140, instead of or in addition to being directly coupled to MSC 110, and may additionally be coupled directly to other BSCs not shown. In such cases the above described statistics may be transmitted direct from the respective BSC to the OMC.

In the above described first and second embodiments, the means for carrying out the various method steps were described as being at or in OMC 130. It is however to be appreciated that such means can be located in other parts of the communications system, and moreover may all be together or may alternatively be distributed at more than one location. The present invention can also be implemented by software or by hardware or by a combination of software and hardware. It is also to be appreciated that component parts of the means to implement the present invention can constitute dedicated equipment or can alternatively consist of existing equipment arranged to perform the herein

described method in addition to still also performing other functions, which other functions may in themselves already be known in the art. When in the form of dedicated equipment, such equipment may be located within existing communications systems parts, such as one or more OMCs, or may alternatively be located remotely in the form of specific dedicated equipment and coupled to the communications system, for example coupled to one or more OMCs.

CLAIMS

1. A method of monitoring a communications system using statistics derived from said communications system;
the method comprising the steps of:
collecting statistics from said communications system; and
statistically analysing said statistics with reference to a threshold;
wherein said threshold is varied.

2. A method as claimed in claim 1, wherein said communications system is a cellular communications system.

3. A method according to claim 1 or 2, wherein said threshold is varied as a function of a sample size of said statistics derived from said communications system.

4. A method according to claim 3, wherein said sample size is divided into a plurality of ranges and said function of a sample size comprises respective functions for each respective range.

5. A method according to claim 3 or 4, wherein one or more of said functions are comprised of a linear equation.

6. A method according to any of claims 2-5, wherein said threshold is varied by means of an operator system from which said function of a sample size and values corresponding to said function can be ascertained by an operator using said operator system.

7. A method according to claim 2, further comprising the step of respectively allocating cells of said cellular communications system into a plurality of

groups according to values of characteristics of said cells; and wherein variation of said threshold comprises employing a respective group threshold value for each respective one of said plurality of groups.

8. A method according to claim 7, wherein said cells are allocated into said plurality of groups automatically and wherein said values of characteristics of said cells comprise statistics collected automatically from said cellular communications system.

9. A method according to claims 7 or 8, wherein said characteristics include a traffic channel usage level.

10. A method according to any preceding claim wherein said statistics comprise a rate of success of call set-up.

11. An apparatus for monitoring a communications system using statistics derived from said communications system;
the apparatus comprising:
means for collecting statistics from said communications system; and
means for statistically analysing said statistics with reference to a threshold;
wherein said threshold is varied.

12. An apparatus as claimed in claim 11, wherein said communications system is a cellular communications system.

13. An apparatus according to claim 11 or 12, wherein said threshold is varied as a function of a sample size of said statistics derived from said communications system.

14. An apparatus according to claim 13, wherein said sample size is divided into a plurality of ranges and said function of a sample size comprises respective functions for each respective range.

15. An apparatus according to claim 13 or 14, wherein one or more of said functions are comprised of a linear equation.

16. An apparatus according to any of claims 13-15, wherein said threshold is varied by means of an operator system from which said function of a sample size and values corresponding to said function can be ascertained by an operator using said operator system.

17. An apparatus according to claim 12, further comprising the step of respectively allocating cells of said cellular communications system into a plurality of groups according to values of characteristics of said cells; and wherein variation of said threshold comprises employing a respective group threshold value for each respective one of said plurality of groups.

18. An apparatus according to claim 17, wherein said cells are allocated into said plurality of groups automatically and wherein said values of characteristics of said cells comprise statistics collected automatically from said cellular communications system.

19. An apparatus according to claims 17 or 18, wherein said characteristics include a traffic channel usage level.

20. An apparatus according to any of claims 11-19, wherein said statistics comprise a rate of success of call set-up.